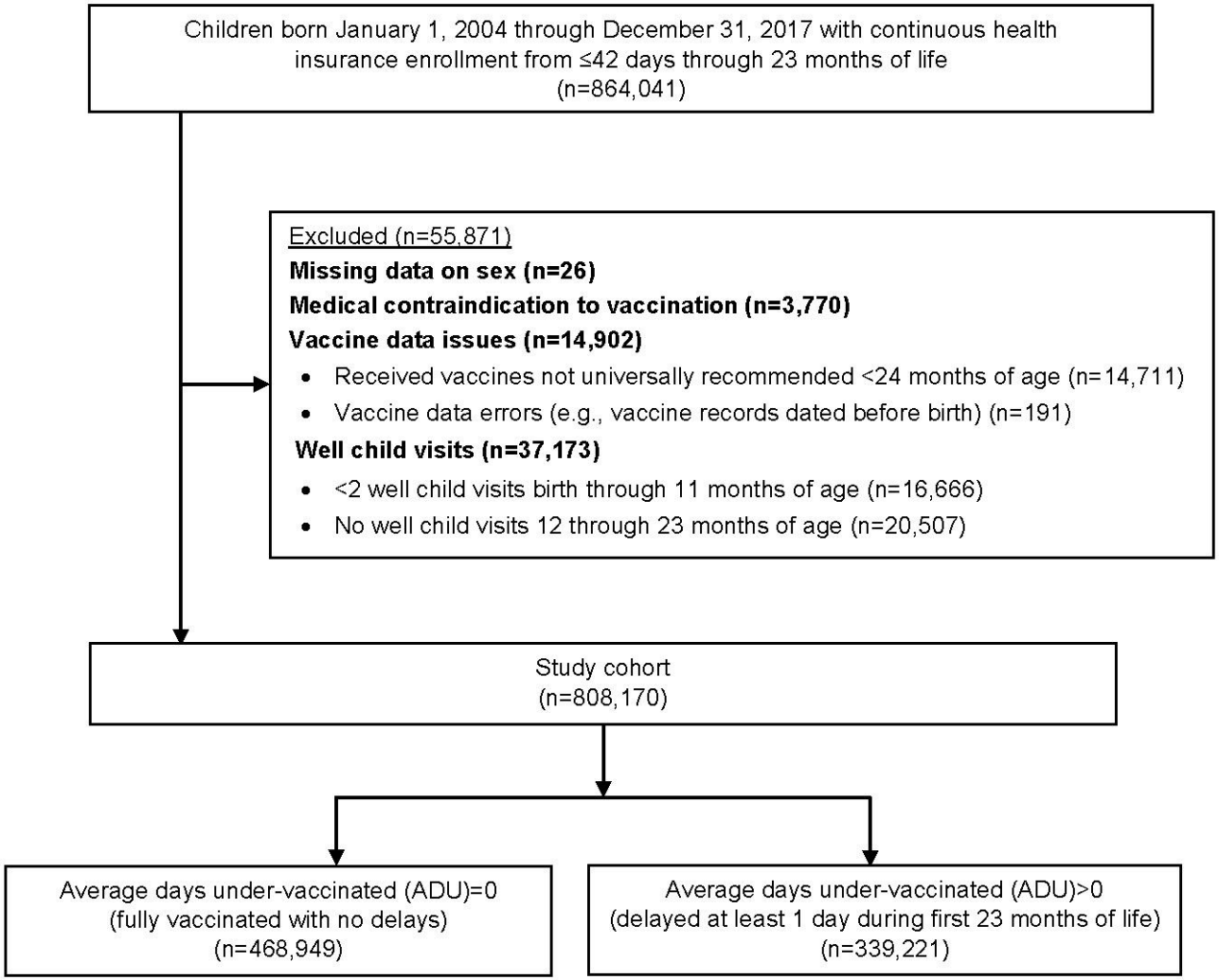
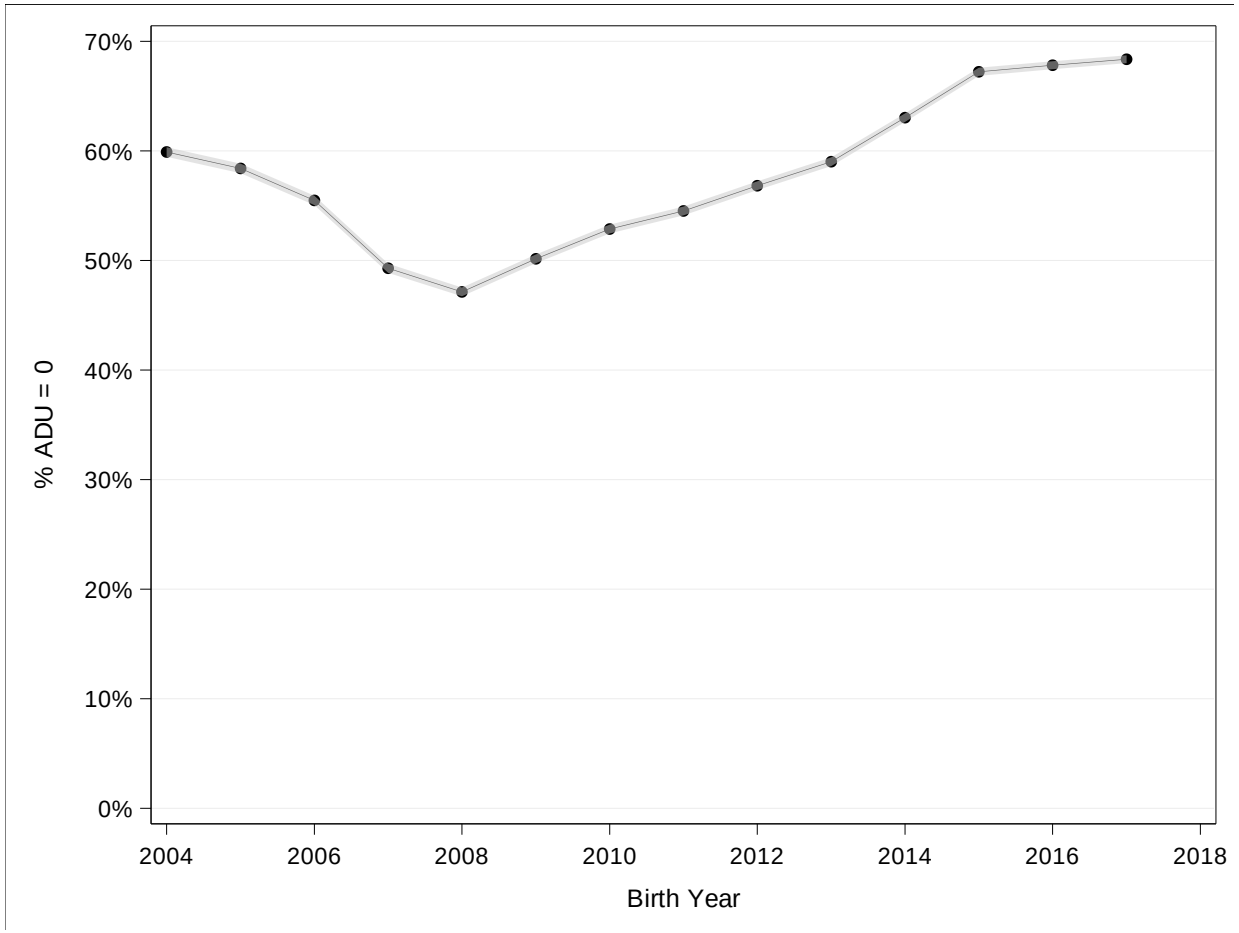
Appendix
Temporal Trends in Under-Vaccination: A Population-Based Cohort Study
Daley et al.

Appendix Figure 1. Study flow diagram.



Note: Average days under-vaccinated was assessed at 23 months of age.
ADU, average days under-vaccinated.

Appendix Figure 2. The percent of children with zero average days under-vaccinated (ADU=0; fully vaccinated with no delays) by birth year, Vaccine Safety Datalink.



Note: Average days under-vaccinated was assessed at 23 months of age.

ADU, average days under-vaccinated.

Appendix Table 1. Temporal Trends in Specific Under-Vaccination Patterns, Children Born 2004 Through 2017 and Followed Through 2019

Year of birth	No vaccines by 23 months of age[a], %	Delayed start: first vaccines age 4-5 months, %	Delayed start: first vaccines age 6-11 months, %	Delayed start: first vaccines age 12-23 months, %	DTaP and rotavirus on different days than PCV and Hib[b], %	Consistent vaccine-limiting[c], %
2004	0.35	0.39	0.19	0.08	0.00	0.35
2005	0.38	0.41	0.18	0.11	0.02	0.37
2006	0.46	0.44	0.21	0.10	0.02	0.37
2007	0.60	0.47	0.27	0.17	0.06	0.65
2008	0.55	0.63	0.30	0.19	0.24	1.53
2009	0.62	0.49	0.30	0.24	0.17	1.75
2010	0.76	0.50	0.24	0.13	0.17	1.85
2011	0.75	0.40	0.23	0.15	0.21	1.74
2012	0.83	0.40	0.20	0.19	0.17	1.79
2013	0.90	0.39	0.25	0.22	0.15	1.79
2014	0.87	0.31	0.17	0.18	0.14	1.73
2015	0.98	0.32	0.24	0.15	0.08	1.75
2016	1.24	0.32	0.24	0.16	0.09	1.77
2017	1.28	0.33	0.20	0.24	0.06	2.04

[a]Ignoring any dose of hepatitis B vaccine received within the first 7 days of life.
[b]A specific alternative (i.e., contrary to recommended) vaccination schedule.
[c]Two or fewer vaccines received at all vaccine visits within the first 11 months of life.

DTaP, diphtheria and tetanus toxoids-acellular pertussis; Hib, *Haemophilus influenzae* type b; MMR, measles-mumps-rubella; PCV, pneumococcal conjugate.

Appendix Table 2. Average Days Under-Vaccinated and Vaccination Visits Among Children With Specific Patterns of Under-Vaccination

Characteristic	No vaccines by 23 months of age[a]	Delayed start: first vaccines age 4–5 months	Delayed start: first vaccines age 6–11 months	Delayed start: first vaccines age 12–23 months	DTaP and rotavirus on different days than PCV and Hib[b]	Consistent vaccine-limiting[c]
ADU[d]						
Mean (SD)	637.0 (0.02)	357.3 (172.4)	522.5 (121.9)	616.0 (36.0)	290.1 (89.5)	250.3 (190.3)
Median	637.0	351.6	564.6	637.0	267.5	224.9
IQR	637.0–637.0	200.1–511.8	448.3–633.0	601.7–637.0	224.9–338.2	70.9–405.1
Number of vaccination visits by age 23 months						
Mean (SD)	0.0 (0.0)	5.2 (2.2)	4.2 (2.2)	2.2 (1.4)	9.9 (2.1)	9.5 (3.8)
Median	0.0	5.0	4.0	2.0	10.0	9.0
IQR	0.0–0.0	4.0–6.0	3.0–5.0	1.0–3.0	9.0–11.0	7.0–12.0

[a]Ignoring any dose of hepatitis B vaccine received within the first 7 days of age.
[b]A specific alternative (i.e., contrary to recommended) vaccination schedule.
[c]Two or fewer vaccines received at all vaccine visits within the first 11 months of life.
[d]Average days under-vaccinated was assessed at age 23 months.

ADU, average days under-vaccinated; DTaP, diphtheria and tetanus toxoids-acellular pertussis; Hib, *Haemophilus influenzae* type b; MMR, measles-mumps-rubella; PCV, pneumococcal conjugate.

Appendix Table 3. Characteristics of Survey Respondents and Non-Respondents for the Parent Under-Vaccination Survey, Administered January Through May 2019

Characteristic	Respondents n=1,444	Non-respondents n=954	*p*-value
Sex, n (%)			0.434
Female	698 (48.3)	486 (50.9)	
Male	745 (51.6)	467 (49.0)	
Race/ethnicity, n (%)			<0.001
Non-Hispanic White	798 (55.3)	412 (43.2)	
Non-Hispanic Black	50 (3.5)	87 (9.1)	
Non-Hispanic Asian	105 (7.3)	54 (5.7)	
Hispanic	204 (14.1)	158 (16.6)	
Other race/ethnicity	70 (4.8)	66 (6.9)	
Missing race/ethnicity	217 (15.0)	177 (18.6)	
Birth year, n (%)			0.199
2016	878 (60.8)	555 (58.2)	
2017	566 (39.2)	399 (41.8)	
ADU category, n (%)			<0.001
ADU=0	296 (20.5)	104 (10.9)	
ADU Quintile 1	257 (17.8)	143 (15.0)	
ADU Quintile 2	251 (17.4)	149 (15.6)	
ADU Quintile 3	226 (15.7)	174 (18.2)	
ADU Quintile 4	228 (15.8)	172 (18.0)	
ADU Quintile 5	186 (12.9)	212 (22.2)	
Diagnosis code for vaccine refusal in EHR, n (%)	316 (21.9)	277 (29.0)	<0.001
Chronic conditions based upon PMCA, n (%)			0.319
No complex or chronic conditions	1,137 (78.7)	769 (80.6)	
Non-complex chronic condition	213 (14.8)	120 (12.6)	
Complex chronic condition	94 (6.5)	65 (6.8)	
Outpatient utilization birth through 11 months of age			
Well-child encounters, mean (SD)	4.5 (0.84)	4.2 (0.91)	<0.001
Outpatient non-well non-ED encounters, mean (SD)	6.1 (6.16)	5.4 (6.76)	0.018
Outpatient utilization 12 through 23 months of age			

Well-child encounters, mean (SD)	2.1 (0.80)	1.8 (0.94)	<0.001
Outpatient non-well non-ED encounters, mean (SD)	3.9 (5.24)	3.5 (5.34)	0.100

ADU, average days under-vaccinated; ED, emergency department; EHR, electronic health record; PMCA, Pediatric Medical Complexity Algorithm.

Appendix Table 4. Parents' Vaccine-Related Attitudes, Stratified by the Degree of Under-Vaccination Observed in EHR Vaccination Data[a]

Question	ADU=0[b]	ADU Quintile 1 (ADU 0.1–9.0)	ADU Quintile 2 (ADU 9.1–21.3)	ADU Quintile 3 (ADU 21.4–60.7)	ADU Quintile 4 (ADU 60.8–205.4)	ADU Quintile 5 (ADU 205.5–457.0)
Responded *yes* to the question:						
Have you ever taken your child to some place other than at [their VSD site name] to get health care?	12.9 (4.1, 21.6)	20.4 (12.0, 28.9)	15.5 (4.7, 26.2)	25.0 (11.9, 38.1)	20.7 (9.1, 32.3)	22.7 (14.4, 31.0)
Has your child received any vaccines at any place other than at [their VSD site name]?	3.6 (0.3, 6.8)	12.3 (9.9, 14.7)	7.6 (2.1, 13.2)	11.8 (1.2, 22.3)	10.5 (3.8, 17.3)	8.8 (1.2, 16.5)
Have you ever decided not to have your child get a vaccine for reasons other than illness or allergy?	1.5 (0.0, 3.5)	8.1 (2.1, 14.0)	13.0 (9.2, 16.7)	14.0 (11.0, 16.9)	19.9 (15.3, 24.5)	53.2 (42.6, 63.8)
Have you ever delayed having your child get a vaccine for reasons other than illness or allergy?	3.2 (1.5, 4.8)	13.9 (9.8, 18.0)	32.4 (25.6, 39.3)	30.9 (24.2, 37.5)	36.0 (28.5, 43.6)	72.6 (55.1, 90.1)
Responded *strongly agree* to the question:						
Children get more vaccines than are good for them.[c]	6.6 (5.2, 8.0)	2.0 (0.0, 4.4)	7.7 (3.8, 11.5)	12.3 (9.7, 14.9)	7.8 (4.5, 11.0)	31.0 (24.8, 37.1)
I believe that many of the illnesses vaccines prevent are severe.	56.5 (50.0, 63.0)	52.1 (34.0, 70.2)	45.2 (38.2, 52.2)	53.0 (34.8, 71.2)	42.8 (35.1, 50.6)	25.6 (7.8, 43.4)
It is better for my child to develop immunity by getting sick than to get a vaccine.[c]	2.1 (1.5, 2.7)	1.7 (0.0, 3.9)	4.6 (3.1, 6.0)	2.6 (0.0, 6.9)	3.9 (0.6, 7.2)	13.2 (6.5, 19.8)
It is better for children to get fewer vaccines at the same time.[c]	3.7 (0.0, 9.3)	14.0 (11.7, 16.3)	29.4 (18.0, 40.8)	37.3 (14.6, 60.0)	23.6 (14.5, 32.7)	55.1 (38.5, 71.7)
I trust the information I receive about vaccines.[c]	39.4 (32.4, 46.3)	27.4 (14.5, 40.4)	29.6 (28.4, 30.8)	19.3 (9.6, 28.9)	15.7 (11.9, 19.5)	6.7 (0.0, 13.9)
Responded *very concerned* to the question:						
How concerned are you that your child might have a serious side effect from a vaccine?	8.8 (6.9, 10.6)	11.7 (7.9, 15.5)	18.2 (10.3, 26.0)	23.4 (12.9, 33.8)	20.3 (13.1, 27.5)	41.0 (30.9, 51.0)
How concerned are you that any one of the childhood vaccines might not be safe?	5.7 (3.7, 7.7)	13.0 (9.2, 16.8)	16.8 (12.2, 21.3)	20.5 (10.9, 30.1)	18.8 (12.8, 24.8)	44.7 (36.7, 52.6)
Responded *very hesitant* to the question:						
Overall, how hesitant about childhood vaccines would you consider yourself to be?[c]	1.1 (0.0, 3.0)	2.6 (2.0, 3.2)	9.1 (6.1, 12.0)	14.6 (8.0, 21.2)	11.5 (5.3, 17.8)	32.1 (29.2, 35.1)

[a]Numbers represent the weighted percentage, with corresponding 95% CIs in parentheses.
[b]Average days under-vaccinated was assessed at 18 months of age for the survey cohort.
[c]These survey questions comprised the 5-item PACV short scale.

ADU, average days under-vaccinated; EHR, electronic health record; PACV, Parent Attitudes about Childhood Vaccines[38,39] scale; VSD, Vaccine Safety Datalink.